ECE 5630: Digital Signal and Image Processing - Two-Dimensional Convolution

Due: October 3, 2017 at midnight

Name (Print):

Objectives

This programming assignment has three objectives:

1. Give you practice in using a program to perform digital signal processing.
2. Help to solidify your understanding of two-dimensional convolution.
3. Observe the effects of three different kinds of image filters.

Instructions

1. The program should be written in C or C++.
2. Use the `image.pgm` file found on the Canvas website to test your program. You can learn about the .pgm image format from a Google search. Remember that the pixels are 8-bit `unsigned char` values. You will need to truncate values greater than 255 to 255, and values less than zero to zero in the filtered images.
3. Write your output images in .pgm format.
4. Use zero padding to extend the input image for convolution.
5. Crop the output image back to the input image size.
6. Upload a short report and output images to the Canvas website. The report should include an introduction, a section describing your approach and findings, and a conclusion. Please include your C/C++ code as an appendix.

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1. Write a program that will read in the provided image, filter with an arbitrary-sized 2D filter, and write out the filtered image.
2. Filter the image with a lowpass filter given by the following:

$$\mathbf{H}_1 = \frac{1}{81}\begin{bmatrix} 1 & 2 & 3 & 2 & 1 \\ 2 & 4 & 6 & 4 & 2 \\ 3 & 6 & 9 & 6 & 3 \\ 2 & 4 & 6 & 4 & 2 \\ 1 & 2 & 3 & 2 & 1 \end{bmatrix} \tag{1}$$

3. A common filter used for finding edges in an image is called a Sobel filter. The Sobel vertical and horizontal filter coefficients are defined as two 3x3 matrices given by

$$\mathbf{S}_1 = \begin{bmatrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{bmatrix} \tag{2}$$

for detecting vertical edges, and

$$\mathbf{S}_2 = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix} \tag{3}$$

for detecting horizontal edges. The two filters are each convolved with the input image $\mathbf{F}$ giving

$$\mathbf{G}_1 = \mathbf{S}_1 * \mathbf{F}, \tag{4}$$

and

$$\mathbf{G}_2 = \mathbf{S}_2 * \mathbf{F}. \tag{5}$$

The absolute value of the resulting images are summed together to create the output image

$$\mathbf{M}(m, n) = |\mathbf{G}_1(m, n)| + |\mathbf{G}_2(m, n)|. \tag{6}$$

Implement the Sobel filter using your program with appropriate modifications.

4. Filter the image with the values in the file `filter.pgm` found on the Canvas site. Before you filter, subtract a scalar value from each value in the filter. The scalar is the minimum value in the filter. Scale the filtered image so that the maximum value in the image is 255, and all negative values after scaling are set to zero. (Scaling should be done *before* you write out the pixel values.)